# PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

## Mixing Hydrocarbonaceous Gases and/or Vapours with Oxygen or Oxygen-containing Gases

We, BADISCHE ANILIN- & SODA-FABRIK AKTIENGESELLSCHAFT, a German Joint Stock Company, of Ludwigshafen/Rhein, Federal Republic of Germany, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following Statement:—

It is known that gaseous hydrocarbons or gas mixtures which contain hydrocarbons may be reacted with amounts of oxygen which are insufficient for complete combustion, with or without an admixture of steam, in contact with catalysts without the formation of a flame, to form synthesis gas or fuel gases. In this method the reactants, if desired saturated with steam, are separately preheated and brought together in a coaxial twist mixer and well mixed before impinging on the cracking catalyst. The mixer usually consists of two tubes arranged concentrically and constricted conically at their outlet ends which are on about the same plane, and of a diffuser. A twist member provided with inclined guide blades is rigidly mounted in the inner tube, into which the oxygen-containing component is usually introduced as propellant. The twist member imparts a spiral twisting motion to the propellant and forces it out at a flow velocity of about 100 metres per second into the hydrocarbonaceous gas mixture flowing from the annular channel between the inner tube and the outer tube. Owing to the difference in the velocities of the two flowing media, the flow currents are broken up and well mixed.

Liquid vaporisable hydrocarbons have also already been reacted with oxygen and steam in contact with catalysts without the formation of a flame to form synthesis gas or fuel gases by the said method with appropriate modifications. In this case, too, the reactants have to be well mixed in a twist mixer prior to impingement on the catalyst. Since, however in the autothermal cracking of liquid vaporisable hydrocarbons or rich gas, for example methane or other normally gaseous hydrocarbons, for the production of an equally large amount of cracked gas, about three times as much oxygen is required as for cracking lean gas, the inner tube of the mixer should have a correspondingly larger diameter. The difference in volume becomes considerably greater if in one and the same plant it is desired to process one of the following combinations only, namely lean gas with oxygen and rich gas or liquid vaporisable hydrocarbons with air or with air enriched with oxygen, or to process them alternately. Adding steam and raising the preheating temperature can increase this difference in volume even further. It is therefore not possible in the case of a cracking furnace whose mixing means is designed for the reaction of lean gas with oxygen to make use even approximately of the capacity when vaporised gasoline is to be cracked with air or oxygen in the same furnace. The many times greater volume of air or oxygen as well as any steam required cannot be passed without a great loss in pressure through the inner tube of a mixer which has been designed for the relatively small amount of oxygen required for lean gas.

If on the other hand a lean gas be cracked with oxygen in a cracking furnace whose mixer has been designed for reacting gasoline with air, oxygen and steam, the flow velocity at the outlet from the mixer decreases from 100 m/sec to about 10 m/sec. The mixing effect is inadequate at this flow velocity. Preliminary reaction takes place in the zone between the mixer and the

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catalyst bed and this makes trouble-free continuous operation of the cracking furnace impossible.

According to this invention, apparatus for mixing hydrocarbonaceous gases and vapours containing a varying amount of hydrocarbons with oxygen or oxygen-containing gas, for example air, for autothermal flameless reaction comprises an outer tube, an inner tube which tapers towards the exit, a twist member having guide blades and a displacement member within said inner tube, the twist member being connected by a spindle to an adjusting mechanism by means of which the displacement member may be moved axially within the inner tube so that the outlet cross section of the inner tube at the outlet thereof through which the oxygen or oxygen-containing gas flows is adjusted to the different amounts of gas.

With the apparatus according to this invention the outlet cross section of the inner tube of the mixer through which the oxygen or oxygen-containing gas flows is adjusted to the different amounts of gas depending on the feedstock and the mixing effect of the apparatus is thereby kept constant. The advantage of the apparatus according to this invention is that an industrial cracking furnace for the autothermal catalytic flameless reaction of hydrocarbons which has been equipped with the new mixer becomes flexible as regards the choice of feedstock and may be switched over for example from lean gas to gasoline hydrocarbons without interrupting operation. This is achieved according to the invention by axial displacement of the displacement member provided with twist blades; in the upper position when the displacement member is in its uppermost position the outlet opening of the inner tube is completely free, whereas when the member is in its lowest position only a narrow annular gap is left open between it and the inner tube. It is advantageous for the mixer to be so dimensioned that, at the maximum effective volume of oxygen component in the case of cracking gasoline with oxygen or air and steam, the flow velocity is about 80 to 150 m/sec when the outlet of the inner tube is fully open. In the case of gradual change-over of cracking to the processing of lean gas with a diminished oxygen requirement, the velocity required for a good mixing effect may be maintained by an appropriate reduction in size of the outlet.

Axial displacement of the displacement member in the inner tube of the mixer may be effected via an appropriate adjusting mechanism connected with the spindle either manually or by means of an automatic regulator, for example one which is operated pneumatically or electrically. An automatic regulator has the advantage that in the event of rapidly changing operating conditions the position of the displacement member is adjusted automatically and to the optimum value for the mixing effect. A device which operates particularly advantageously is one in which the pressure difference between the inner tube of the mixer through which the oxygen component flows and the outer tube through which the hydrocarbonaceous gas or vapour flows which is necessary for a good mixing effect is set on a regulator (differential pressure regulator) as the required value, the said regulator acting on the adjusting mechanism for the displacement member in the inner tube of the mixer until the displacement member has changed the outlet cross section to such an extent that the pressure difference reaches the required value. When using this automatic system there is free choice as regards the feedstock from lean gas up to gasolines during the operation of a cracking furnace and the throughput may be varied within wide limits without risk of pre-ignition.

When working under the same conditions with a prior art mixer whose nozzles cannot be adjusted, and if safe operation is to be ensured, the choice of feedstock is very limited and the throughput can only be varied within narrow limits without modification of the mixer.

The invention will now be described with reference to the accompanying drawings which show diagrammatically one embodiment of apparatus according to the invention, Figure 1a showing the inner nozzle substantially open and Figure 1b showing it substantially closed.

The position as shown in Figure 1a is suitable for cracking rich gas or liquid vaporisable hydrocarbons having a high oxygen requirement. In Figure 1b the nozzle of the inner tube is closed to such an extent that in the cracking of lean gas with a low oxygen requirement the outflow velocity from the inner tube achieves the value required for good mixing. The two Figures differ only in the position of the displacement member and may therefore be described together.

Oxygen or air, if desired saturated with steam, passes through a supply line into the inner tube 1 of the mixer. A twist member 3 having guide blades and a displacement member 4 is located within the inner tube 1, and is connected by a spindle 2 with an adjusting mechanism 5. A spiral twisting motion is imparted to the oxygen or air by the guide blades of the twist member 3 and it then passes at a velocity of 50 to 200 m/sec, particularly 80 to 150 m/sec, through the orifice of a nozzle 6 into a stream of hydrocarbon fed through a

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1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

Fig. 1a

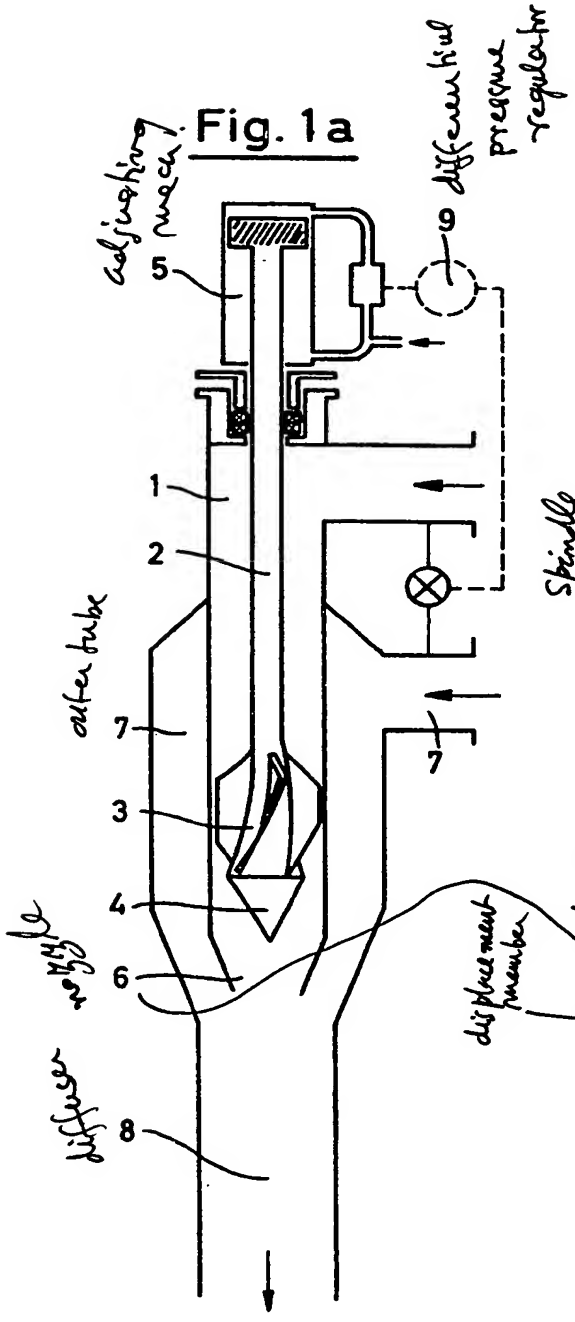
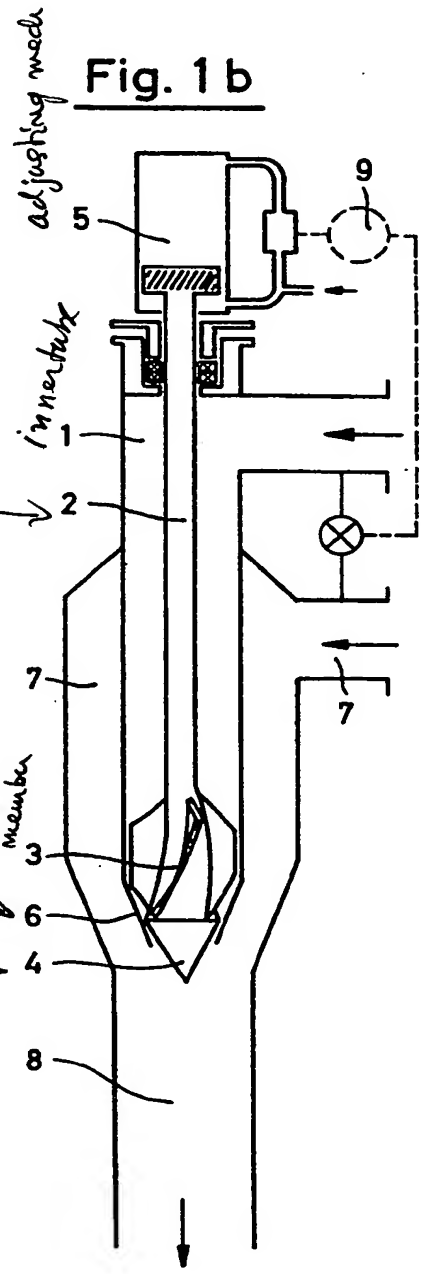



Fig. 1b



supply line into the outer tube 7 of the mixer. Good mixing is achieved by the difference in the velocities of the two media. The mixture passes through a diffuser 8 into the catalyst chamber of the cracking furnace (not shown).

The differential pressure set up between the inner tube 1 and the outer tube 7 produces an impulse by which, through a differential pressure regulator 9 and the pneumatically operated adjusting mechanism 5, the displacement member 4 is adjusted in such a way that good mixing of the two streams of gas takes place in the diffuser 8. The differential pressure between tubes 1 and 7 set by the differential pressure regulator 9 is in general 0.5 to 5.0, particularly 1.0 to 3.0, metres water column.

Cracking furnaces provided with mixing means according to this invention may be used without interrupting operation for processing hydrocarbonaceous gases and vapours in which the hydrocarbon content varies within a wide range in nature and amount, for example lean gas having a calorific value of 2000 to 4000 kcal/cu.m. (STP), such as flashed gases, and rich gas having a calorific value of 9000 to 20,000 kcal/cu.m. (STP), such as methane, ethane, propane. Natural gas, refinery gas, liquefied gases, light naphthas and other vaporisable petroleum distillates may also be processed.

WHAT WE CLAIM IS:—

1. Apparatus for mixing hydrocarbonaceous gases and vapours having a varying content of hydrocarbons with oxygen or oxygen-containing gas for autothermal flameless reaction comprising an outer tube and an inner tube which tapers towards the exit, a twist member incorporating guide blades and a displacement member located in the inner tube and connected by a spindle with an adjusting mechanism by which the displacement member may be displaced axially in the inner tube so that the outlet cross section of the inner tube through which the oxygen or oxygen-containing gas flows can be adjusted to the varying amount of gas in the inner tube.

2. Apparatus as claimed in claim 1 wherein the adjusting mechanism is actuated by a differential pressure regulator so that an impulse which the differential pressure regulator receives from the differential pressure between the outer and inner tubes causes axial displacement of the displacement member so that the outlet area of the inner tube through which the oxygen or oxygen-containing gas flows is adjusted to the varying amount of gas in the inner tube.

3. Apparatus as claimed in claim 1 substantially as herein described with reference to the accompanying drawings.

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